sierra

TRADE MARK

INSTRUCTION MANUAL

DIRECTIONAL COUPLER
MODELS 138, 138A

PHILCO

A SUBSIDIARY OF Ford Motor Company

SIERRA ELECTRONIC DIV.

3885 BOHANNON DR., MENLO PARK, CALIFORNIA

Stock No. 950000019

Warranty

SIERRA ELECTRONIC DIVISION, PHILCO CORPORATION warrants instruments manufactured by it and bearing Sierra commercial model numbers, except Ion Gauge Tubes, to be free from defective material and factory workmanship and agrees to repair such instruments, which under normal use and service, disclose the defect to be the fault of our manufacturing. Our obligation under this warranty is limited to repairing any such instrument which in our sole opinion upon our examination proves to be so defective, when returned to our factory, transportation prepaid by the purchaser, within one year from the date of original purchase from us.

This warranty does not apply to any of our products which have been repaired, worked upon or altered by persons not authorized by us so as, in our sole judgment, to injure the stability or reliability of such instrument, or which have been subject to misuse, negligence or accident, or the serial number of which has been altered, effaced, or removed. Neither does this warranty apply to any of our products which have been connected, installed, used or adjusted otherwise than in accordance with the instructions furnished by us. Nor does SIERRA ELECTRONIC DIVISION, PHILCO CORPORATION assume any liability for consequential damages, and in any event our liability shall in no case exceed the original purchase price of the instrument. Accessories, including but not limited to all vacuum tubes, fuses and batteries, not of our manufacture used with this product are not covered by this warranty.

SIERRA ELECTRONIC DIVISION, PHILCO CORPORATION reserves the right to make changes in the design or construction of any of its instruments at any time without incurring any obligation to make any changes whatever on units previously purchased.

This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to represent nor assume for us any liability in connection with the sale of our products other than set forth herein.

Manufactured by

PHILCO
A SUBSIDIARY OF Ford Motor Company

sierra
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3885 BOHANNON DR., MENLO PARK, CALIFORNIA

AREA CODE 415

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OPERATING INSTRUCTIONS
For
DIRECTIONAL COUPLER

MODELS 138, 138A

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OPERATING INSTRUCTIONS
For
DIRECTIONAL COUPLER

MODELS 138, 138A

1. GENERAL

The Model 138 (or 138A) coupler is a "four terminal" network designed to be used with an external voltmeter and terminating resistance to measure either the incident or reflected waves existing in the primary coaxial transmission line. The coupler may be used to measure reflection coefficient, monitor power, mix signals, or isolate signal sources.

2. SPECIFICATIONS

(a) Primary line impedance: Model 138 =51.5 ± .5 ohms
Model 138A=50.0 ± .5 ohms

(b) Secondary line impedance: 51.5 ohms ± 1 ohm

(c) COUPLING FACTOR (defined as the ratio between power applied to primary line and power derived from secondary line):

49.5 db ± 1 db at 100 mc (typical values). Decreases 6 db per octave with increasing frequency. See attached graph.

(d) DIRECTIVITY (defined as the ratio between forward and reverse powers in the secondary line when unidirectional power exists in the primary line):

61 db ± 3 db at 100 mc (typical values). Decreases 6 db per octave with increasing frequency. See attached graph.

3. CIRCUIT DESCRIPTION AND OPERATING THEORY

The straight primary line is coupled within the coupler body to the parallel section of the secondary line through a small hole in the wall between the two lines, thus providing both inductive and capactive coupling between them. See Figure 1. A small screw is provided in the secondary line center conductor to permit adjustment of the capactive component of coupling. The value of the mutual inductance is controlled by the hole diameter and is not adjustable.

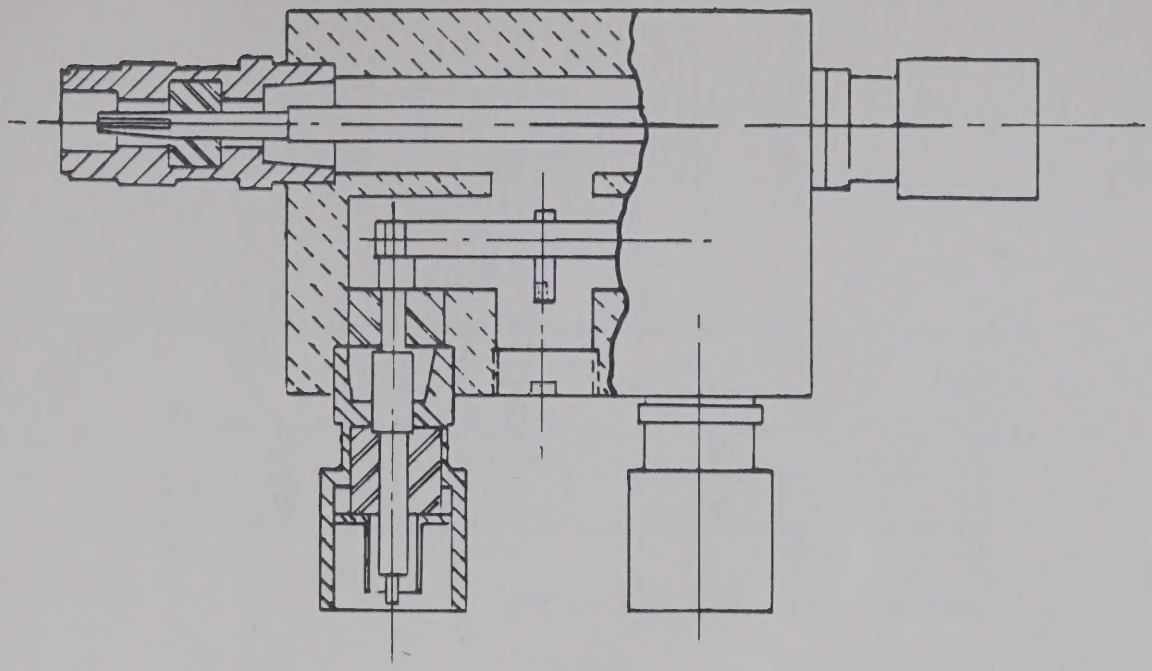
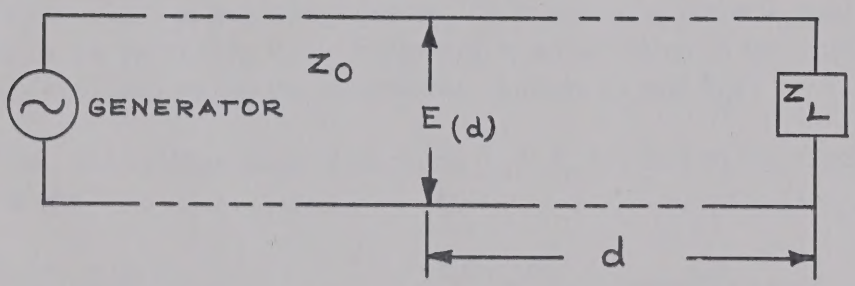


FIG. I

FIG. II



In Figure II a generator is shown connected to a load impedance Z_l through an arbitrary length of transmission line of characteristic impedance Z_o. At any point to the left of the load a distance d, a line-to-line voltage E_d and a line current I_d can be measured. It has been shown that both E_d and I_d are composed of the vector sums of incident and reflected components. The vector relations are:

1. $E_d = E_i + E_r$, and
2. $I_d = (E_i - E_r)/Z_o$

Where E_i is the incident wave voltage and E_r the reflected wave voltage.

The load and line impedances are related to the incident and reflected voltages at the load as follows:

3. $E_r/E_i = (Z_l - Z_o)/(Z_l + Z_o) = \rho \angle \varphi$

This equation defines ρ as the reflection coefficient.

Fig. III

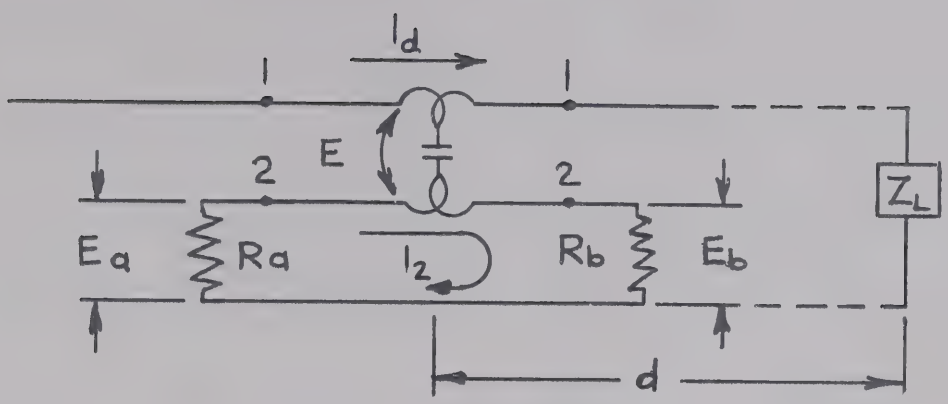


Fig. III shows the equivalent circuit of the coupler connected to a load through a transmission line. For convenience, no attempt is made to show the line as coaxial. The primary line 1-1 is coupled to the secondary line 2-2 by M and C as explained above. Terminating resistors R_a and R_b are connected to the secondary line. Following is a derivation of the voltages E_a and E_b developed across the terminating resistors R_a and R_b:

First, the voltage developed across $R_a = R_b = R$ due to the capacitive coupling alone is:

4. $$V_{rc} = \frac{R/2}{R/2 - j\frac{1}{\omega C}} \qquad E_d = \frac{\omega \quad CR}{\omega \quad CR - j\,2} \qquad E_d$$

5. Since $\omega\ CR \ll 1$, 5 becomes

6. $$V_{rc} = \simeq j \frac{\omega \quad CR}{2} \quad E_d$$

Next, the voltages developed across R_a and R_b due to the coupling through M alone are:

7. $$V_{rm} = - \frac{j\omega \quad M}{2} \quad I_d = i_2 R_b = i_2 R_a$$

Since the circuit elements are linear, the total voltage across each resistor is that due to the capacitive coupling plus that due to the magnetic, or:

$$E_a = j\frac{\omega CR}{2} E_d - j\frac{\omega M}{2} I_d$$

8.

$$E_b = j\frac{\omega CR}{2} E_d + j\frac{\omega M}{2} I_d$$

Substituting relations 1 and 2 into 8 and adjusting, (by means of the screw referred to above):

9. $C = \frac{m}{RZ_o}$ we have

10. $E_a = CRE_r = j\frac{\omega M}{Z_o} E_r$ and

$E_b = CRE_i = j\frac{\omega M}{Z_o} E_i$ which is the result desired.

Note that the reciprocal of either coefficient of E_i in 10 is the coupling factor.

The directivity of the coupler is determined by how scrupulously condition 5 is met. In this case, if the primary line is perfectly matched, i.e., $E_r = O$, and if equation 4, rather than the approximation 6, is substituted into 8, we find:

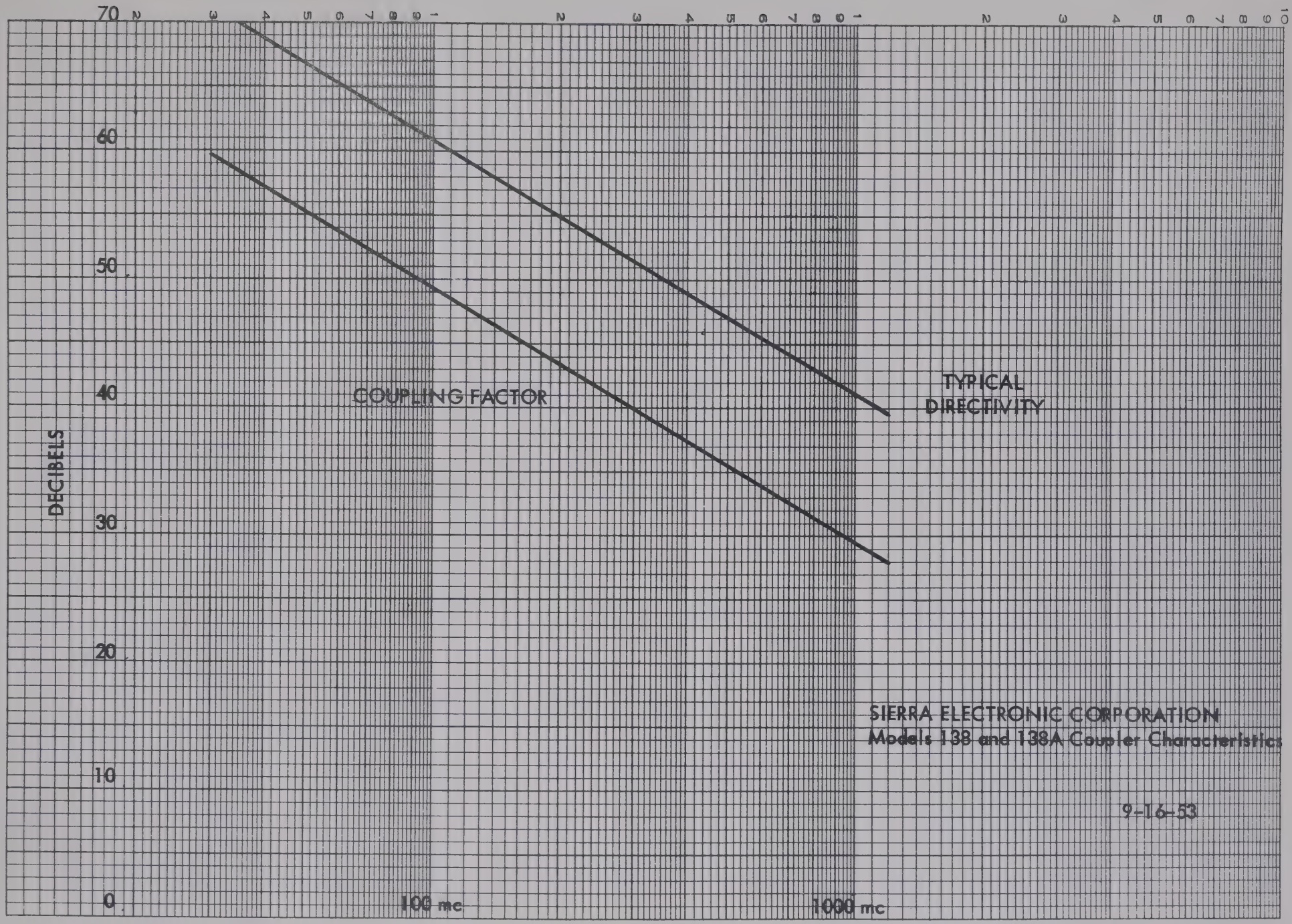
11. $$\frac{EB}{E_a} = \frac{4+j\omega CR}{-j\omega CR} = \frac{4}{-j\omega CR}$$

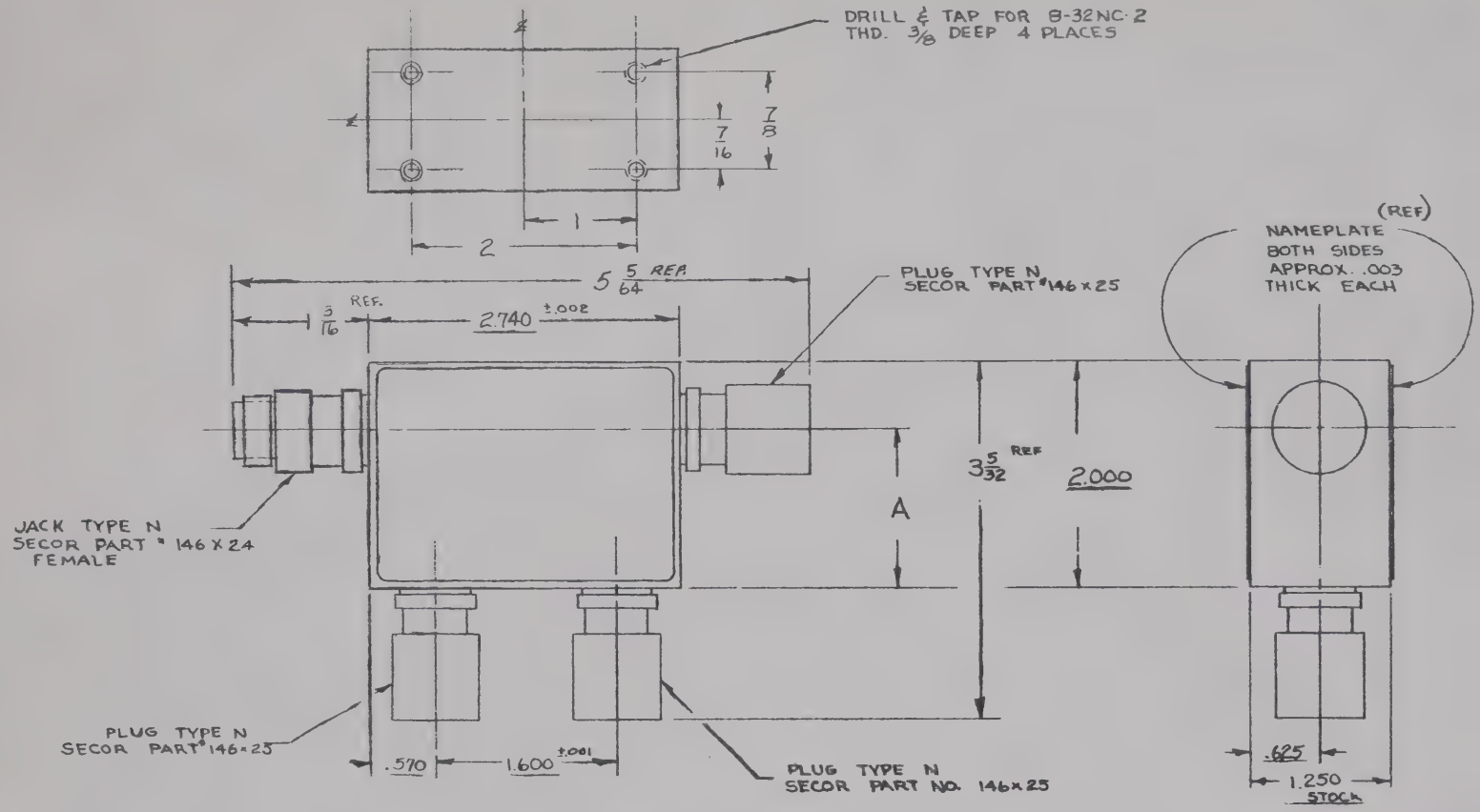
This is the ideal directivity for the Model 138 coupler. Note that it is four times the coupling factor at every frequency. Discontinuities in the coupler fittings and in the secondary line bends cause the directivity to vary around this figure by plus or minus 3 db over the frequency range from 30 to 1200 mc.

4. APPLICATION NOTES

Each coupler is tested for performance at the factory before shipment. The resistor used to terminate the secondary line during testing has a value of 51.50 ohms and no measurable reactance at 500.00 mc where adjustments are made. If the secondary line termination employed by the purchaser is not identical to that used in the factory tests the directivity and sensitivity will be affected. The user may desire to adjust the coupler to optimize performance using his particular terminations. This is accomplished by removing the screw plug between the E_r and E_i terminals and by adjusting the capacitor screw thus exposed with an insulated screwdriver.

CAUTION: Avoid bending the secondary line center conductor, and be sure that no foreign matter enters the coupler.


70
60
50
40
30
20
10
0
DECIBELS
COUPLING FACTOR
TYPICAL
DIRECTIVITY
100 mc
1000 mc
SIERRA ELECTRONIC CORPORATION
Models 138 and 138A Coupler Characteristics
9-16-53



MTG. SPEC. NO	DIM. A	MODEL NO.
SP-7297-2-1	1.400 ±.002	137-1, 137A-1, 138-1, 138A-1, 145-1
SP-7297-2-2	1.285 ±.002	150-1

FINISH:
ALODINE

DIRECTIONAL COUPLER OUTLINE MOUNTING DIMENSIONS

Sierra Electronic Corp.
SAN CARLOS, CALIFORNIA

TOLERANCE DEC DIM ± .005 FRACT DIM ± 1/64 UNLESS OTHERWISE SPECIFIED

DRAWN AV. & B.B.	SP-7297-2	REVISE B
CH'K'D. APP'D		
DATE 10/21/55		
SCALE FULL	SHEET NO. OF	SHEETS

PARTS REPLACEMENT

To help in identifying and ordering replacement parts, the REPLACEMENT PARTS LIST contains the circuit symbol, commercial description and Sierra stock number.

To order parts from Sierra Electronic Division:

1. Give Sierra stock number of part to be ordered.
2. Give circuit symbol and commercial description of part to be ordered.
3. State name, model and serial number of the equipment containing part to be ordered.
4. Send order to:

SIERRA ELECTRONIC DIVISION
Philco Corporation
3885 Bohannon Drive
Menlo Park, California

For further service information on this unit, contact

SIERRA ELECTRONIC DIVISION
Philco Corporation
3885 Bohannon Drive
Menlo Park, California

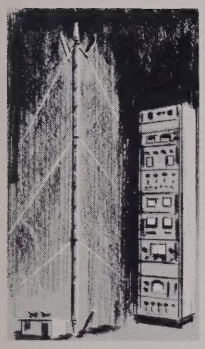
Area Code 415

Telephone 326-2060

TWX 492-9224

The Sierra Electronic Division is just one of eight Philco divisions currently serving the needs of the government and the military. Their combined capabilities and talents represent an integrated organization with wide experience in all phases of electronic technology.

PHILCO STRUCTURE for Defense Electronics



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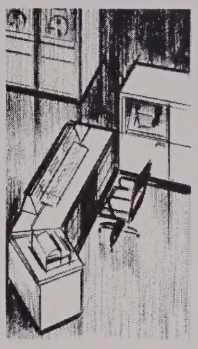

Computer Division

3900 Welsh Road, Willow Grove, Pa.

Philco 2000 series of large-scale electronic data processing systems for military, government and scientific applications; and Basicpac mobile military computer systems.

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515 Pennsylvania Ave., Ft. Washington, Pa.

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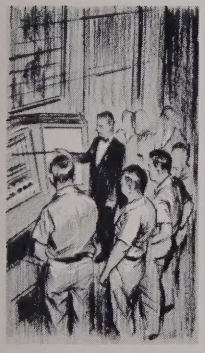
3875 Fabian Way, Palo Alto, Calif.

System manager for space programs and ground support systems for space. Capabilities include system design and integration, complete vehicle systems and sub-systems, satellite control systems, range instrumentation systems, and other specialized space equipment.



TechRep Division

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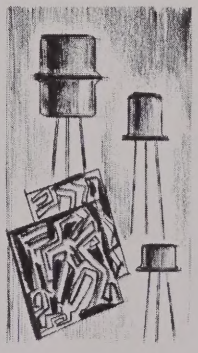
A world-wide field engineering organization providing contract technical services in the fields of engineering, installation, maintenance, operation, technical training and technical publications.



Lansdale Division

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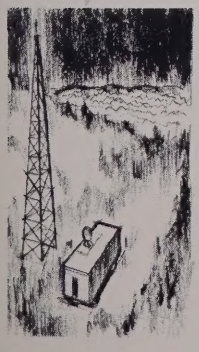
A pioneer producer of germanium and silicon transistors, microwave diodes, IR detectors, microelectronic circuits and other solid state devices for switching and communications applications, high-speed semiconductor test equipment, and special purpose cathode ray tubes.



Sierra Electronic Division

3885 Bohannon Drive, Menlo Park, Calif.

Development engineering and manufacturing of special purpose equipment and systems, including: communications and R.F. power test equipment, monitoring systems, R.F. power amplifiers and transmitters at all power levels and frequencies, navigational and telemetry systems.

Scientific Laboratory

Union Meeting & Jolly Roads, Blue Bell, Pa.

Provides the basic and applied research support for the Corporation in all engineering and scientific disciplines. Main areas of investigation are: electronic materials and components; communications and detection; recognition, learning, and automation; mathematical physics.